2.22 DETAILED RESULTS FOR MOVING TARGET INDICATOR

No errors or discrepancies were found for Moving Target Indicator (MTI) in ESAMS 2.6.2. Overall code quality is good and internal documentation is adequate.

The verification matrix shown in Table 2.22-1 summarizes the desk-checking and software testing verification activities for design elements in the MTI functional element. A check mark appears in the results columns if no discrepancies were noted.

The two SAM systems of interest both use the notch filter implementation of MTI described by the first two design elements. Thus, only Design Elements 22-1 and 22-2 were tested, although all design elements were manually examined.

TABLE 2.22-1. Verification Matrix for Moving Target Indicator FE.

Design Element	Code Location	Desk Check Result	Test Case ID	Test Case Result
22-1: Unambiguous Doppler Frequency	CLUREJ	√	22-1	√
22-2: Notch Filter Signal Attenuation	CLUREJ	√	22-1	√
22-3: Delay-Line Signal Output	MTIREX 41-47 MTIAEX 47-71 MTIRNG all	√	*	*
22-4: MTI Output Normalization	MTIREX 48-53 MTIAEX 72-90	√	*	*
* These design elements were not tested because they do not apply to the systems of interest.				

2.22.1 Overview

Many radar systems use MTI to distinguish between signal returns that are stationary and those that are in motion. General MTI methodology involves a bandstop filtering process that removes the DC component of a signal return. ESAMS 2.6.2 models MTI using two methods: an idealized notched filter and delay-line cancellation.

The notched filter implementation can be used by any radar system modeled in ESAMS whereas the delay-line implementation can be used only in conjunction with Track While Scan (TWS) systems. Since neither of the two systems examined under this effort were TWS radars, the three subroutines that form the delay-line canceler representation were not software tested. The four subroutines that form both implementations are described in Table 2.22-2.

TABLE 2.22-2. Subroutine Descriptions.

Module Name	Description
CLUREJ	Performs MTI attenuation using idealized notch filter
MTIAEX	Processes each signal in the scan plane channels for the delay-line canceler application
MTIREX	Processes each range channel signal for the delay-line canceler application
MTIRNG	Computes attenuated signals for the delay-line canceler application

2.22.2 Verification Design Elements

The design elements defined for the MTI functional element are listed in Table 2.22-3 below according to the subroutines in which they appear. Design elements are algorithms or features that represent specific components of the FE design. They are fully described in Section 2.22.2 of ASP II. The first two design elements described the notch filter implementation; the second two describe the delay-line canceler implementation.

TABLE 2.22-3. MTI Design Elements.

SUBROUTINE	DESIGN ELEMENT	DESCRIPTION
CLUREJ	22-1: Unambiguous Doppler Frequency	Compute the unambiguous doppler frequency of all signal components.
CLUREJ	22-2: Notch filter signal attenuation	Compute attenuated signals using delay-line canceler.
MTIAEX MTIREX MTIRNG	22-3: Delay-Line signal output	Compute attenuated signals using delay-line canceler.
MTIAEX MTIREX	22-4: MTI output normalization	Divide delay-line canceler output by the square of the total number of delay lines.

2.22.3 Desk Checking Activities and Results

The code implementing this FE was manually examined using the procedures described in Section 1.1 of this report. No discrepancies were discovered and code quality was assessed as good.

Internal documentation problems are characterized in Table 2.22-4.

TABLE 2.22-4. Internal Documentation Results.

Subroutine	Internal Documentation
MTIAEX MTIREX	Each time one of these subroutines is called, the values of VOLD (I,J) from its previous execution are used as arguments in the call to MTIRNG. Since standard FORTRAN 77 does not guarantee values of local variables will be saved from one subroutine execution to the next, a comment should be included to explain the use of this array.
MTIRNG	A comment explaining VOLD should also be included in this subroutine.

2.22.4 Software Test Cases

Software testing was performed by running the entire model in debug mode. The standard data files for the systems under consideration were used as input for all test cases.

Only subroutine CLUREJ was tested since the other subroutines implement the delay-line filter design that does not apply to the systems of interest. Since the coded logic in subroutine CLUREJ is relatively simple (eight lines of simple arithmetic and one conditional construct), one main software test was performed to ensure proper operation. This test consists of examining a target Doppler frequency as it ranges over several pulse repetition frequencies (PRFs) while at the same time examining the notch filter attenuation factor. This factor should be unity except when the target doppler falls within the stop band around zero frequency and the stop band frequency range around multiples of the PRF.

TABLE 2.22-5. Software Test Case for Notch Filter MTI.

Test Case ID	Test Case Description
22-1	Objective: Check MTI attenuation in CLUREJ Procedure: 1. Define a target flight path and run ESAMS. Initial position (1000.0, -1000.0, 60.0) Velocity 145 m/s Heading 90˚ 2. Stop in subroutine CLUREJ at line 108 3. Note the values of UNPRF, DOPMAG, ATNMTI, DIFCNT, HLFWTH, and ATTEN 4. Repeat steps 2 and 3 until DOPMAG > UNPRF. Verify: 1. If DIFCNT ≥ HLFWTH, Then ATTEN=ATNMTI 2. If DIFCNT< HLFWTH, then ATTEN = 1.0 Result: OK

2.22.5 Conclusions And Recommendations

2.22.5.1 Code Discrepancies

As a result of the verification activities described in the previous sections, it has been determined that the FE is correctly implemented in the code and that the coded implementation performs as expected and as specified by Section 2.22 of ASP II.

2.22.5.2 Code Quality and Internal Documentation

Code quality is generally good and internal documentation is adequate. One problem found relates to the complex array VOLD (I,J). Subroutines MTIAEX and MTIREX receive values of VOLD as arguments passed back after the call to MTIRNG. VOLD (I,J) is the signal output from stage J-l of the delay-line canceler for signal component I. It is computed in MTIRNG for the current pulse to be used as the delayed input to stage J for the next pulse. Subroutines MTIAEX and MTIREX use a nonstandard FORTRAN feature to save these values until the next time they are executed, so the VOLD values can be sent back to MTIRNG to be used as the old values. This is a subtle, nonstandard programming technique that should be explained in a comment.

2.22.5.3 External Documentation

External documentation was not assessed because no documentation specifically for ESAMS V.2.6.2 has been released.